RF Project 1227
Final Report

THE OHIO STATE UNIVERSITY

RESEARCH FOUNDATION

1314 KINNEAR ROAD COLUMBUS 12, OHIO

MAPPING GLACIERS IN WESTERN UNITED STATES

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FINAL REPORT

by

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RESEARCH FOUNDATION

1314 Kinnear Road

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On **MAPPING GLACIERS IN WESTERN UNITED STATES**
Burroughs Glacier
Dinwoody Glacier
Palisade Glacier

Grant No. NSF-G1 5997

(Successor to RF Project 943)

For the period 21 December 1960 - 31 December 1961

Submitted by Dr. Arthur J. Brandenberger

Project Supervisor

Department of Geodetic Science

Date January 1962

FOREWORD

This report was prepared by Dr. Arthur J. Brandenberger, Project Supervisor, Department of Geodetic Science and The Institute of Polar Studies of The Ohio State University, under National Science Foundation Grant No. NSF - G1 5997, OSURF Project No. 1227. The grant is administered under the direction of Dr. Alan T. Waterman, Director, National Science Foundation.

OSURF Project No. 1227 covers research performed by Dr. Arthur J. Brandenberger, Project Supervisor; Dr. James B. Case, Mr. O. M. Miller, Mr. Sanjib K. Ghosh, Mr. Robert B. Forrest, Miss M. W. Hindman, Research Associates, and Mr. Peter Wilson, Research Assistant, of The Department of Geodetic Science, The Ohio State University.

A portion of this report covers results reported in detail in the Final Report of RF Project No. 943, prepared by Dr. James B. Case.

ABSTRACT

The subject of this research is the preparation of photogrammetric maps of the Burroughs Glacier in Alaska, the Dinwoody Glacier in Wyoming and the Palisade Glacier in California. These maps were compiled in the scale 1:5000 with a contour interval of five meters, according to specifications established for the IGY Project 4.11.

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I. PURPOSE AND SCOPE

The task of this research is the compilation of photogrammetric maps of the Burroughs Glacier, the Dinwoody Glacier and the Palisade Glacier in the scale 1:5000 with five meter contour lines. This mapping is to be repeated periodically to determine various changes of the glaciers, such as volumetric changes, in function of time. RF Project No. 1227 covers only the first mapping of the three glaciers. Repetition of such mapping at later times would require additional grants.

II. PROJECT SPECIFICATIONS

As far as such specifications were established, they were previously outlined in the Final Report of RF Project No. 943. Among other items, these specifications anticipate that the procurement of the necessary aerial photography and the determination of required ground control is to be taken care of by the grantee.

III. LOCATION AND DESCRIPTION OF THE GLACIERS

Burroughs Glacier is located at 136° 20' west longitude and 58° 57' north latitude at the head of Wachusett Inlet in Glacier Bay National Monument, Alaska. The width of the glacier varies from, approximately, one kilometer to four kilometers and the glacier is, approximately, 13.5 kilometers long. Burroughs Glacier appears on the Mt. Fairweather (D-1 and D-2) quadrangles (1954 and 1950), 1:63360 series, of the United States Geological Survey. The surface of the glacier rises from sea level to approximately 500 meters above sea level.

Dinwoody Glacier is located at 109° 38' west longitude and 43° 11' north latitude in the Wind River Range of Wyoming, about 33 kilometers south of the town of Dubois. The glacier is in a large northeast-facing cirque on the southeast side of Gannett Peak and is about two kilometers long and three kilometers wide and ranges from 3,100 to 4,000 meters above sea level. Dinwoody Glacier appears on the Fremont Peak quadrangle (1906), 30 minute series, of the United States Geological Survey.

Palisade Glacier is located at 118° 31' west longitude and 37° 06' north latitude in the Sierra Nevada of California, about 20 kilometers west-southwest of the town of Big Pine. This glacier is about two kilometers wide and one kilometer long and ranges from 3,700 to 4,000 meters above sea level. Palisade Glacier lies in a cirque directly to the north of North Palisade Peak and appears on the Mt. Goddard quadrangle (1948), 15 minute series, of the United States Geological Survey.

The location of these three glaciers is shown in Fig. 1.

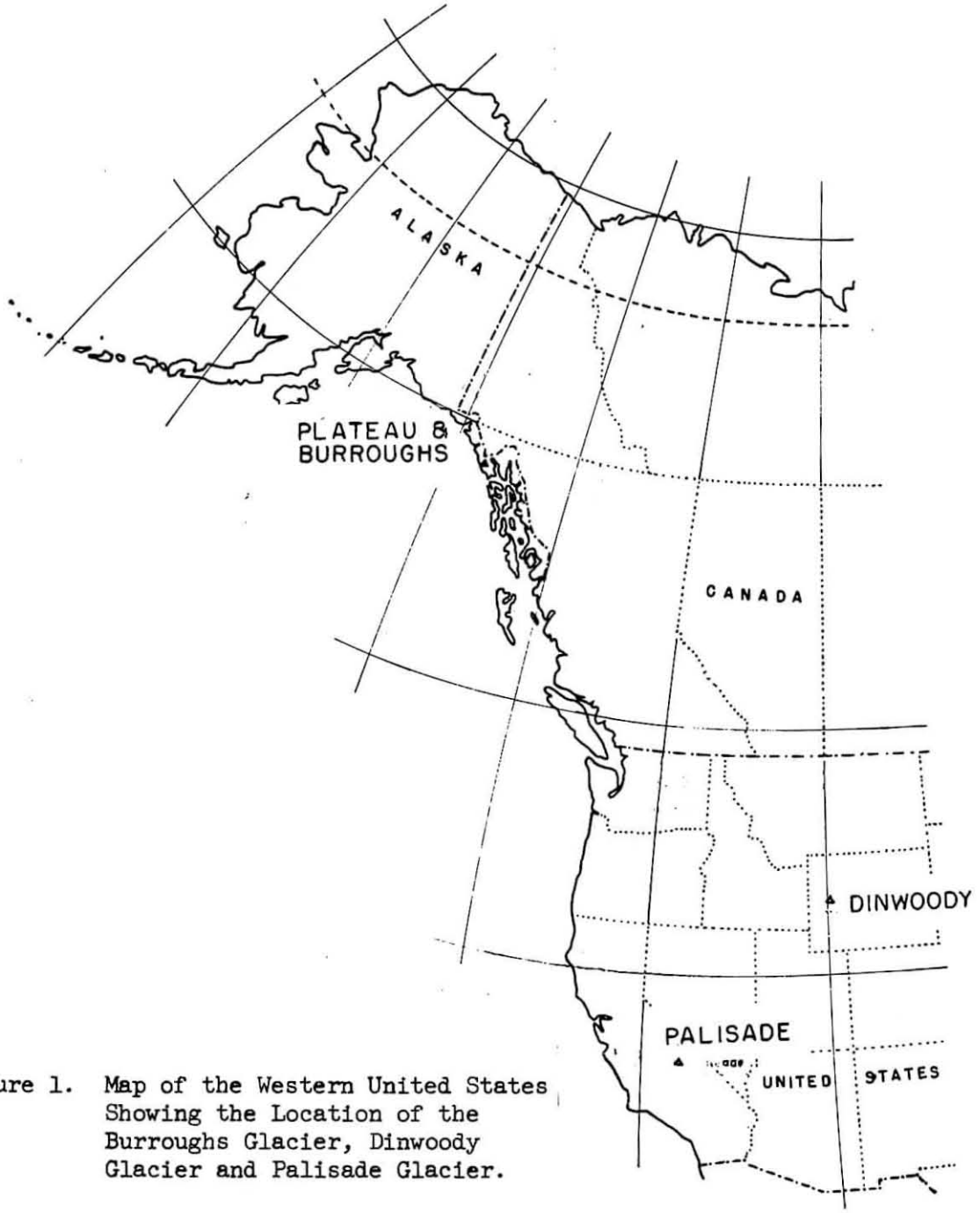

Figure 1. Map of the Western United States Showing the Location of the Burroughs Glacier, Dinwoody Glacier and Palisade Glacier.

IV. AERIAL PHOTOGRAPHY

The flight plans to photograph Burroughs Glacier, Dinwoody Glacier, and Palisade Glacier were prepared by Dr. James B. Case. Missions were performed by Pacific Aerial Surveys of Seattle, Washington using a K 17 Metrogon camera with a format 9 x 9 inches and a calibrated focal length f = 153.21 mm. For all three glaciers 60 per cent vertical photography were exposed. The technical data of these missions are:

Burroughs Glacier

Date of mission: August 11, 1960

Flight altitude above average ground approx:

(Two flight lines) 16,000 ft.

(Two flight lines) 8,000 ft.

Dinwoody Glacier

Date of mission: September 10, 1960

Flight altitude above sea level approx:

(Three flight lines) 22,000 ft.

Palisade Glacier

Date of mission: August 2, 1960

Flight altitude above sea level approx:

(One flight line) 22,000 ft.

V. DETERMINATION OF FIELD CONTROL

The determination of ground control points necessary to compile the 1:5,000 scale maps of the three glaciers from the available aerial photography was performed by Dr. James B. Case during the summer period 1959. This operation is described in the Final Report of OSURF Project No. 943. The system of field measurements are shown in Figs. 2a, 2b, and 2c.

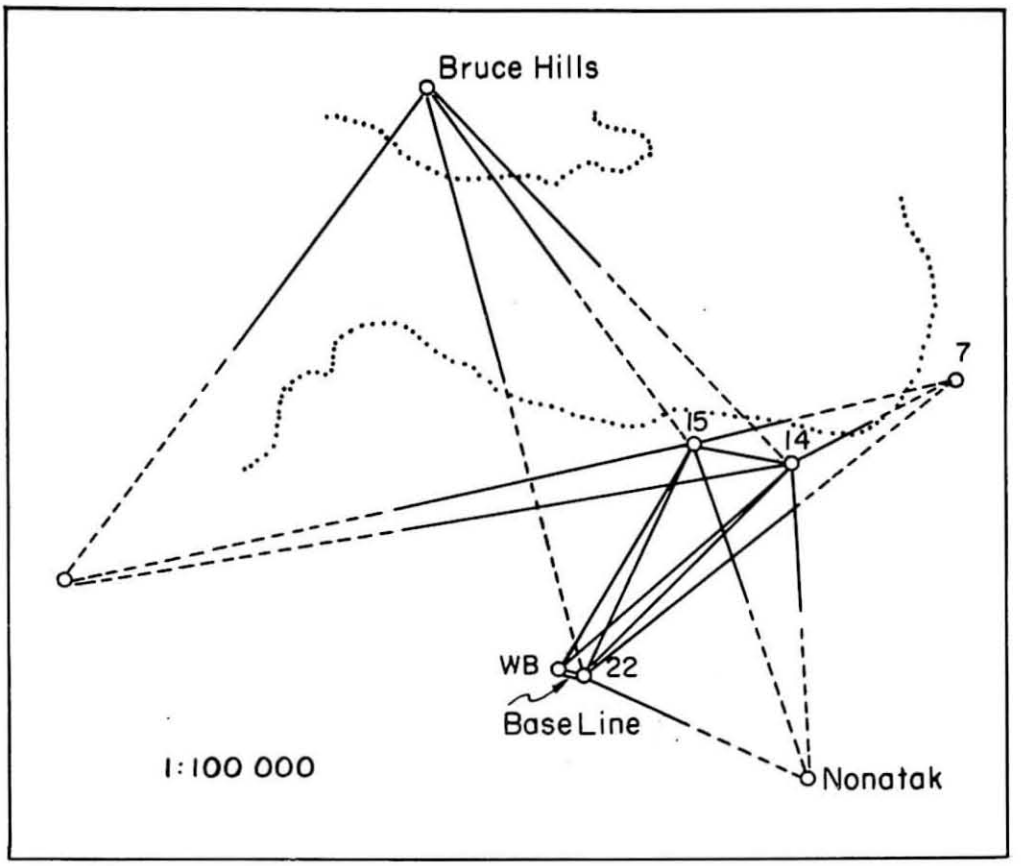

Figure 2a. Burroughs Glacier. Sketch Map of the Control Survey Network.

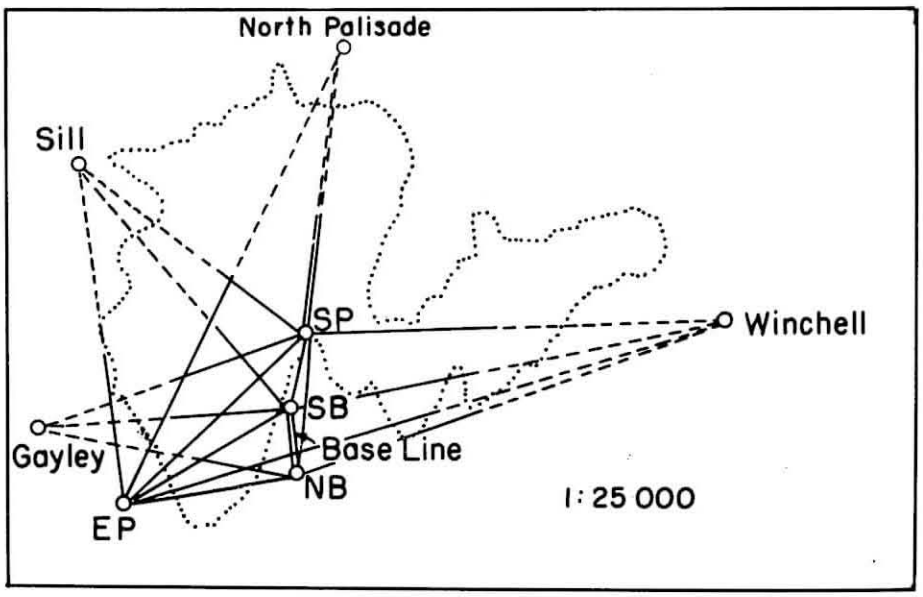

Figure 2c. Palisade Glacier. Sketch Map of the Control Survey Network.

For the determination of the various ground control points geodetic triangulation was applied (base line measurements, resection, intersection, and vertical angle measurements). The ground control points were usually marked with cairns wrapped with aluminum foil. Third order methods and standards, as specified by The United States Coast and Geodetic Survey were used. Horizontal and vertical angles were measured with a Kern DKM 2 one-second theodolite and for the base line measurements a 500 ft. steel tape was used. The approximate position, orientation, and elevation datum for each glacier was determined from the available topographic maps of The United States Geological Survey. For the Burroughs and Palisade Glaciers, already existing control could be included in the survey systems.

The local rectangular coordinates and elevations of the measured ground control points are shown in the following tables.

TABLE Ia

BURROUGHS GLACIER

Ground Control Points

Points	X	Y	H	Marking
	Meters	Meters	Meters	
7	1738.4	4755.3	330.4	panel
14	2627.3	6462.8	243.2	panel
15	3643.2	6896.5	182.1	panel
Bruce Hills	8174.2	5548.9	659.2	panel
Nonatak	Not used			
22	Not used			
Peak 2	Not used			

TABLE Ib

DINWOODY GLACIER

Ground Control Points

Points	X	Y	H	Marking
	Meters	Meters	Meters	
South Base SB	2130.5	2000.0	3444.0	Cairn
North Base NB	2000.0	2000.0	3428.6	Cairn
Lake	1488.6	2659.0	3301.6	Cairn
Outcrop	2158.5	1187.9	3602.6	Cairn
1	3956.5	2379.3	4158.5	Top of peak
2	3881.6	892.4	4043.4	Top of peak
3	2337.0	458.8	3990.5	Top of peak
4	1585.8	538.5	3974.6	Top of peak
Gannett Pk.			4201.7	Top of peak
B			4057.5	Top of peak
C			3818.0	Top of peak
D			3615.7	Top of peak

TABLE Ic

PALISADE GLACIER

Ground Control Points

Points	X	Y	H	Marking
	Meters	Meters	Meters	
North Base NB	3214.6	2000.0	3759.0	Cairn
South Base SB	3000.0	2000.0	3783.5	Cairn
East Pt. EP	3265.1	1419.6	3760.2	Cairn
Gayley	2973.9	1075.3	4091.5	Top of peak
Sill	2119.3	1355.5	4299.3	Top of peak
N. Palisade	1801.7	2275.9	4332.7	Top of peak
Winchell	2817.8	3476.3	4187.8	Top of peak

The points in Tables I are pricked and marked on the paper prints of the aerial photographs.

VI. AERIAL TRIANGULATION

Due to an insufficient number of available ground control points for the plotting of the Burroughs Glacier, additional control points had to be determined by aerial triangulation using the Wild Autograph A 7. This aerial triangulation was performed by Mr. Sanjib K. Ghosh.

Since the entire area, except for a small portion, is covered by the high-flown photography it was considered sufficient to triangulate the two adjacent high-flown strips, in which case they could also be used for subsequent plotting. The small gap area had to be plotted from two adjacent low-flown models for which the necessary control points were supplied from the high-flown photography.

The performance of the aerial triangulation of the two high-flown strips required a special approach since there is practically no vertical control available on the inland. Also, the available horizontal control is very meager (there are only four horizontal control points available in the block formed by the adjacent high-flown strips and these points show an unfavorable distribution).

Basically, these strips were triangulated at the Wild Autograph A 7 by triangulating both strips according to the Aeropolygon method forward and backward. In the first strip covering essentially the Burroughs Glacier area, eight models had to be triangulated forward and backward. In the second strip covering essentially the Plateau Glacier and small portions of the Burroughs Glacier, also eight models had to be triangulated forward and backward. Scaling and absolute orientation of the first model (1-2) of the Burroughs Glacier strip had to be performed by means of distance 14-15 and the sea level. After the last model was set up the same model was reoriented with inversed base in such a way that the same machine coordinate values were obtained. The strip was then triangulated backward up to the first model (1-2). The Plateau Glacier strip was triangulated in the same fashion with model 7-6 as the starting model. The absolute orientation of this model was established by means of the sea level while the scale had to be set approximately since no ground control points were available in this model.

The adjustment of the Burroughs Glacier strip was performed by means of the four available ground control points 7, 14, 15 and Bruce Hills, according to adjustment methods used in aerial triangulation. Since there are no ground control points available in the Plateau Glacier strip this strip had to be tied to the Burroughs Glacier strip by means of common points in the sidelap area of both strips and by using a plane rectangular coordinate transformation utilizing three common points and including a scale correction which was also applied to the elevations.

The relative accuracy of the control points determined by aerial triangulation was evaluated and it was found that the standard planimetric errors are in the order of 1 to 1.5 meters (0.2 to 0.3 millimeters in the plotting scale - 1:5,000) while the standard elevation error amounts to about 0.5 meters. This accuracy has to be considered as sufficient for the mapping of the Burroughs Glacier in the scale 1:5,000 with five meter contour lines. A schematic of the available ground control points and the control points determined by aerial triangulation is shown in Fig. 3.

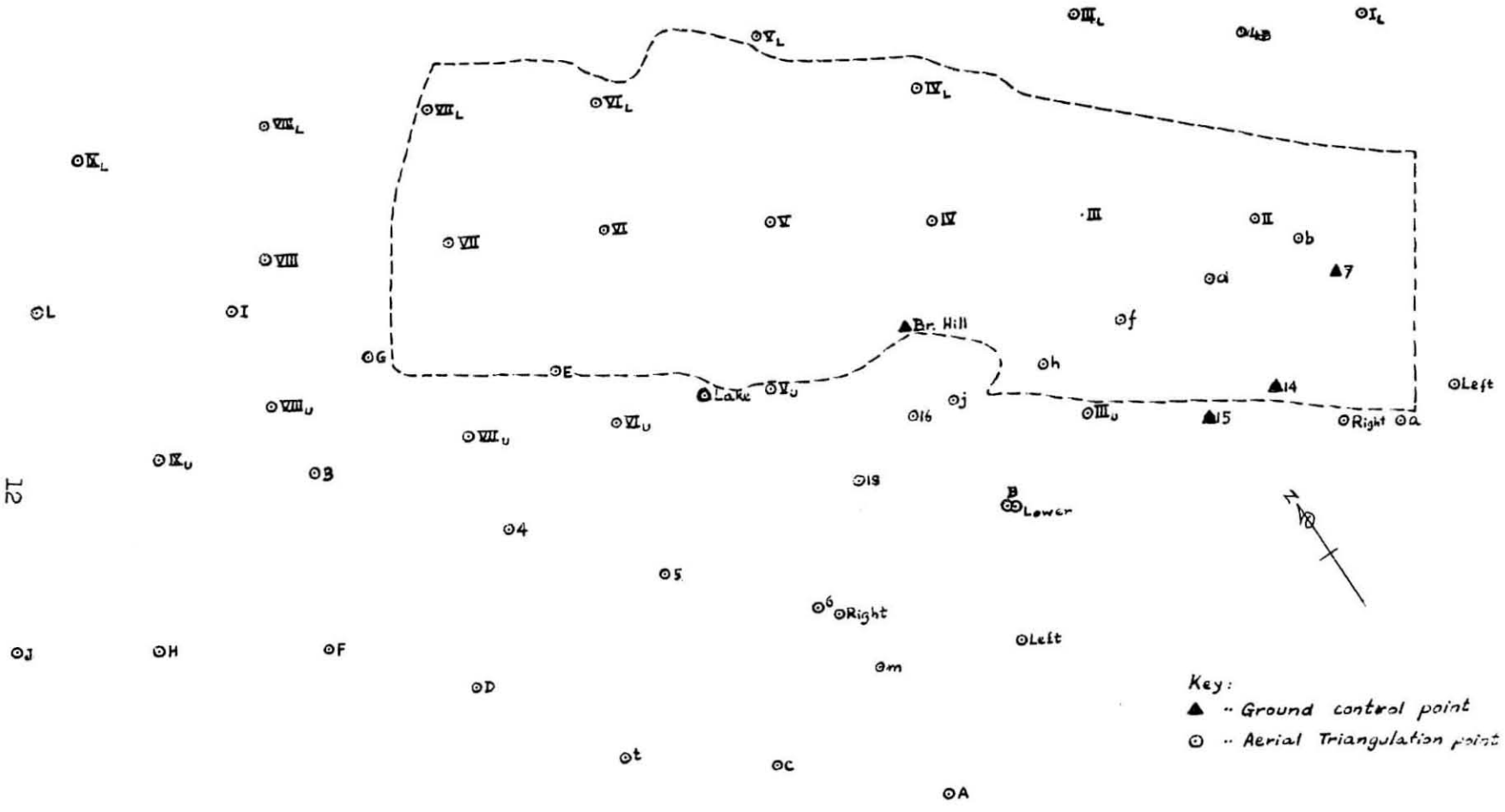

Figure 3. Schematic Showing the Available Ground Control Points and the Control Points Determined by Aerial Triangulation in the Block Formed by the Burroughs Glacier Strip and the Platteau Glacier Strip.

The adjusted ground coordinates and elevations of the control points determined by aerial triangulation are shown in Table II.

TABLE II

ADJUSTED GROUND COORDINATES

and

ELEVATIONS OF CONTROL POINTS

DETERMINED BY AERIAL TRIANGULATION

BURROUGHS GLACIER

Point	X Meters	Y Meters	H Meters	Description of Point
Stn 7	1738.38	4755.31	330.4	Aluminum foil covered rock
Stn 14	2627.26	6462.78	243.2	Aluminum foil covered rock
Stn 15	3643.16	6896.49	182.1	Aluminum foil covered rock
Bruce Hill	8174.25	5548.90	659.2	
a	754.35	6878.23	1.6	Sketches and descriptions
b	2285.48	4221.18	187.4	of the following points
d	3637.55	4840.84	238.2	are in the file of The
f	4924.28	5466.10	288.9	Department of Geodetic
h	6096.81	6053.09	247.0	Science.
j	7374.25	6600.51	193.2	
E	13323.04	6134.78	524.4	
G	16110.61	5909.61	75.2	
I	18091.70	5175.64	161.0	
L	21069.77	5249.00	232.8	
I L	829.31	816.82	1.8	
II	2893.13	3696.65	188.0	
III U	5386.02	6855.81	137.6	
III	5468.82	3841.92	381.4	
III L	5589.10	825.78	163.8	
IV	7772.56	3934.81	481.5	

TABLE II

(continued)

Point	X Meters	Y Meters	H Meters	Description of Point
IV L	7867.70	1862.02	751.4	
V U	10131.08	6379.49	657.06	
V	10143.57	3924.24	472.6	
V L	10297.97	1118.78	542.8	
VI U	12452.00	6913.70	243.6	
VI	12585.69	3998.07	361.1	
VI L	12733.36	2155.11	718.0	
VII U	14651.30	7131.08	142.5	
VII	14959.58	4226.94	187.7	
VII L	15179.00	2240.64	614.6	
VIII U	17523.46	6612.48	78.6	
VIII	17590.21	4405.20	480.6	
VIII L	17640.98	2419.06	291.1	
IX U	19222.32	7411.03	174.2	
IX L	20367.87	2914.59	432.3	
16	8056.21	6861.58	217.0	
Left Burroughs	-69.67	6499.45	2.2	
Right Burroughs	1606.08	6957.99	2.4	
Lake	11095.37	6466.05	688.2	
4 B	3108.22	1092.29	111.3	

VII. PLOTTING

The plotting of the Burroughs Glacier, Dinwoody Glacier, and the Palisade Glacier was performed by Mr. Sanjib K. Ghosh and Mr. Robert B. Forrest, Research Associates, at the Wild Autograph A 7. Reduced copies of these maps are shown in Figs. 4a, 4b, and 4c.

Figure 4a. Burroughs Glacier.

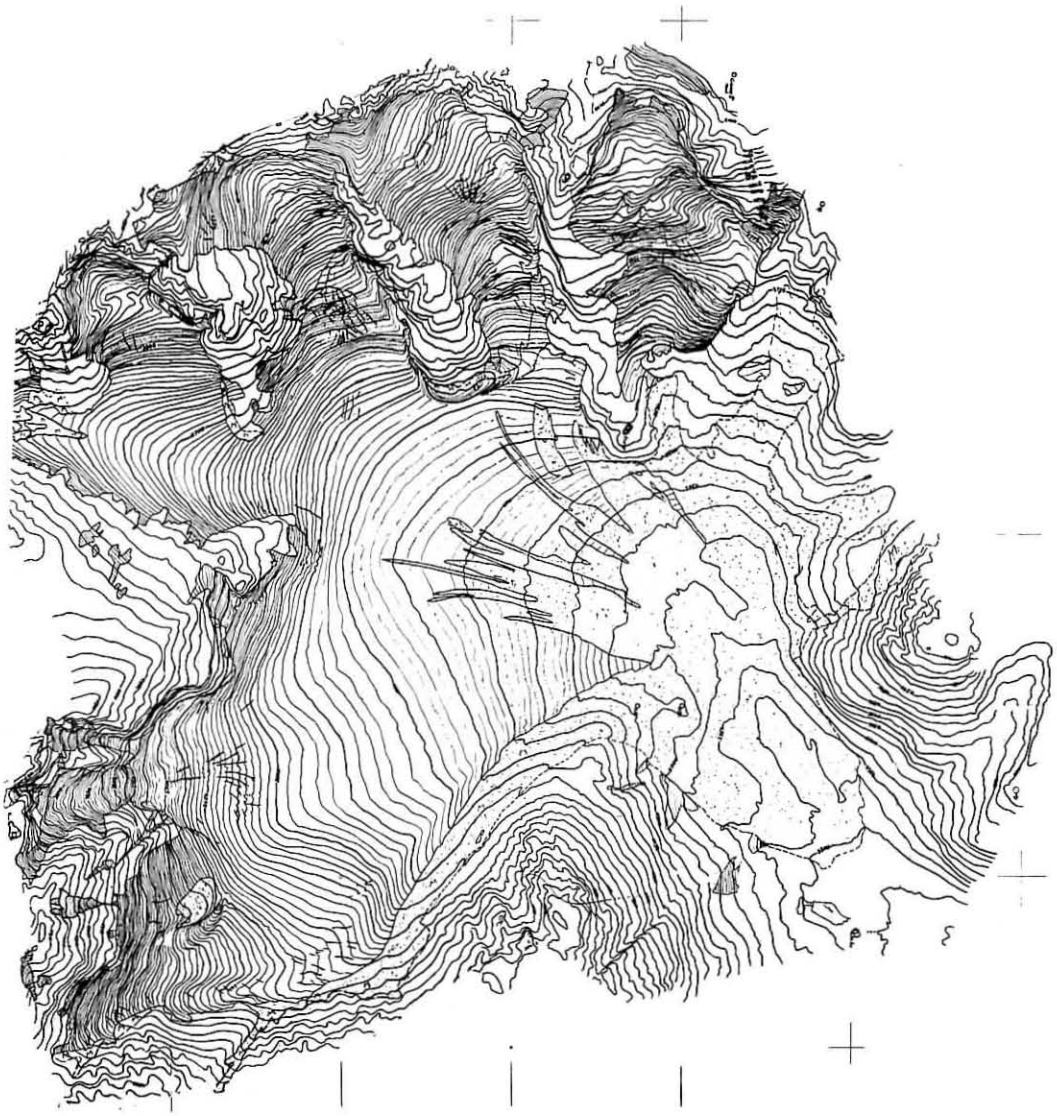

Figure 4b. Dinwoody Glacier.

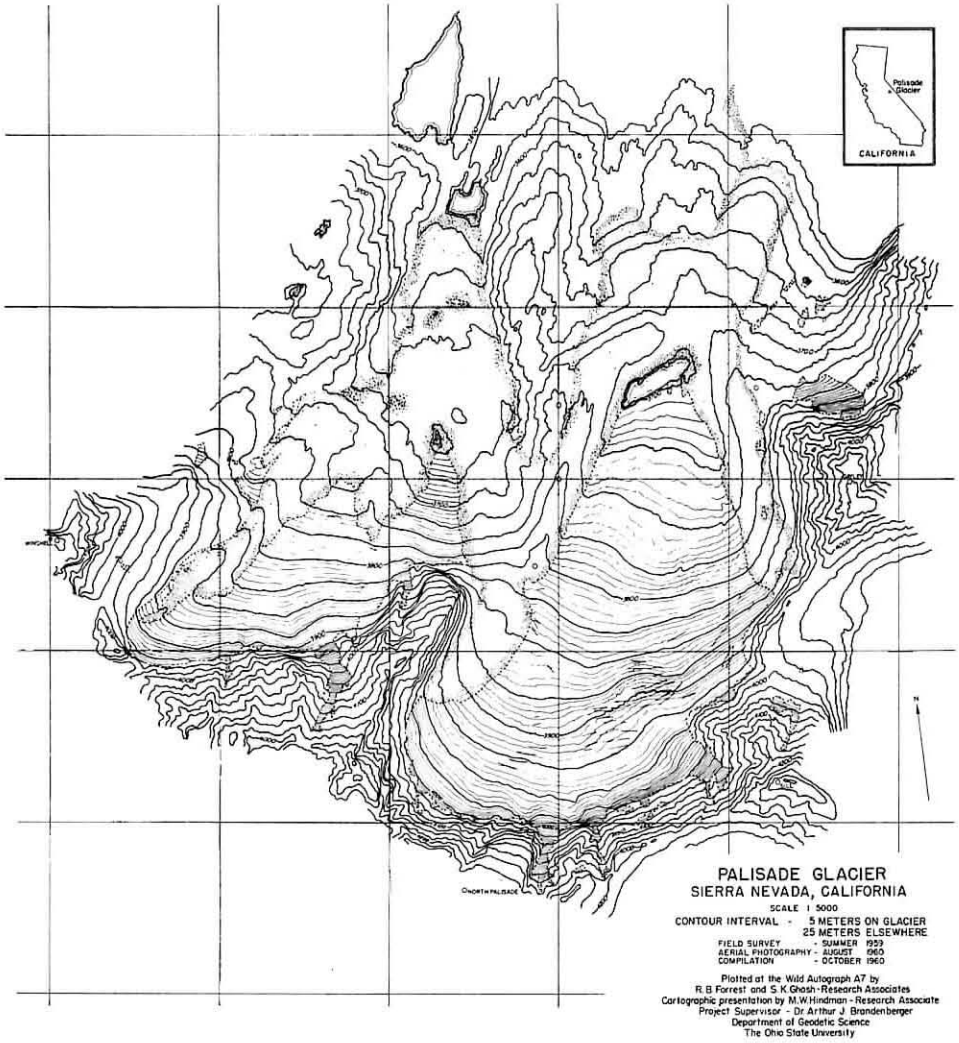

Figure 4c. Palisade Glacier.

The number of models plotted are

Burroughs Glacier:	Six models
Dinwoody Glacier:	Two models
Palisade Glacier:	Two models

For the compilation of the original map manuscripts stable cardboard was used on which previous to the plotting all control points were plotted using the coordinatograph of the Wild Autograph A 7. To represent the topography 5 meter contour lines on the glacier surface and 25 meter contour lines outside the glaciers were plotted.

The cartographic presentation on stabeline for reproduction purposes was done by Miss M. W. Hindman, Research Associate.

VIII. CONCLUSIONS AND RECOMMENDATIONS

Work under this project has shown that the identification of the field control points on the paper copies of the aerial photography was not performed with the necessary care. Furthermore, no detailed sketches of these points were made during the field campaign. For future photogrammetric glacier mapping it is important that more attention be given to these essential items since a good description and sketching of the ground control points is a vital prerequisite in photogrammetric mapping.

The scientific significance of such photogrammetric glacier mappings is highly increased by periodical remapping of these glaciers in intervals of three to five years. Such a program will make available valuable glaciological information on ice movement as well as on volumetric variations of the glacier concerned.

Therefore, it is recommended that this program be extended and that the necessary funds be made available to re-map the glaciers covered in OSURF Project No. 943 and No. 1227 in intervals of three to five years and that each glacier be remapped at least three times.

Supervisor Arthur J. Brandenberger Date Febr. 8 1962

Executive Director Oram C. Woolpert Date 2/19 1962